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characters of a lake, and has considerable resemblance to the madder lake, which he has described in his treatise on dyeing cotton. The other two were blues, one pale, but the other deep and rich. They were both produced by a combination of oxide of copper, with lime and alumina, resulting from a commencement of vitrification. As this blue is much superior to verditer, and might be fabricated at a much less expense than

ultramarine, or the blue from cobalt, it would be of great advantage to discover the processes employed by the ancients for producing it.

Mr. Sage has been endeavouring to ascertain the processes best adapted to the extraction of quick-lime, for obtaining solid mortars; the nature of different kinds of stucco; the means of giving the polish of marble to artificial stones; and a process for making soap of white wax.

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### DISCOVERIES AND IMPROVEMENTS IN ARTS, MANUFACTURES, &c.

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#### *Observations upon Luminous Animals.*

*By J. Macartney, esq.*

THE property which certain animals possess of emitting light is so curious and interesting that it has attracted the attention of naturalists in all ages. It was particularly noticed by Aristotle and Pliny amongst the ancients; and the publications of the different learned societies in Europe contain numerous memoirs upon the subject. Notwithstanding the degree of regard bestowed upon the history of luminous animals, it is still very imperfect; the power of producing light appears to have been attributed to the several creatures which do not possess it; some species which enjoy it in an eminent degree have been imperfectly described or entirely unobserved; the organs which afford the light in certain animals have not been examined by dissection; and, lastly, the explanations that have been given of the phenomena of animal light are unsatisfactory, and in some instances palpably erroneous.

As this subject forms an interesting part of the history of organized beings, I had for some years availed myself of such opportunities as

occurred for its investigation. Having communicated the result of some of my researches to the Right Hon. Sir Joseph Banks, he immediately offered me his assistance with that liberality which so eminently distinguishes him as a real lover of science. I am indebted to him for an inspection of the valuable journal he kept during his voyage with Captain Cook; for permission to copy the original drawings in his possession of those luminous animals discovered in both the voyages of Cook; and for some notes upon the luminous appearance of the sea, that were presented to him by Captain Horsburg, whose accuracy of observation is already known to this learned society.

In the following paper I shall first examine the grounds on which the property of shewing light has been ascribed to certain animals that either do not possess it, or in which its existence is questionable. I shall next give an account of some luminous species, of which some have been inaccurately described, and others quite unknown. I shall endeavour to explain, from my own observations, and the information

communicated to me by others, many of the circumstances attending the luminous appearance of the sea. I shall then describe the organs employed for the production of light in certain species; and, lastly, I shall review the opinions which have been entertained respecting the nature and origin of animal light, and relate the experiments I have made for the purpose of elucidating this part of the subject.

The property of emitting light has been reported to belong to several fishes, more particularly the mackerel, the moon-fish, (*tetraodon uola*) the dorado, mullet, sprat, &c.

Mr. Bajon observed, during the migration of the dorados, &c. that their bodies was covered with luminous points. These however proved, upon examination, to be mere spherical particles that adhered to the surface of these fishes; and, he adds, appeared to be precisely the same sort of points that illuminated the whole of the sea at the time. They were therefore, in all probability, the minute kind of medusa which I shall have occasion to describe hereafter.

Godeheu de Riville states, in a paper sent to the academy of sciences at Paris, that on opening the scomber pelamis while alive, he found in different parts of its body and oil which gave out much light: but it should be observed, that Riville had a particular theory to support, for which this fact was very convenient, and that other parts of his memoir bear marks of inaccuracy. It may be added, that if the oil of fishes were usually luminous, which Riville supposed, it would be almost universally known, instead of resting on a solitary observation.

As far as I am able to determine from what I have seen, the faculty of exhibiting light during life does not belong to the class of fishes. It ap-

pears probable, that some fishes may have acquired the character of being luminous from evolving light soon after death.

Some species of *lepas*, *murex*, and *chama*, and some star-fish, have been said to possess the power of shining; and the assertion has been repeated by one writer after another, but without quoting any authority.

Brugueire upon one occasion saw, as he supposed, common earth-worms in a luminous state; all the hedges were filled with them; he remarked that the light resided principally in the posterior part of the body\*.

Flaugergués pretended to have seen earth-worms luminous in three instances; it was at each time in October; the body shone at every part, but most brilliantly at the genital organs†.

Notwithstanding this concurrence of testimony, it is next to impossible that animals so frequently before our eyes as the common earth-worm should be endowed with so remarkable a property without every person having observed it. If they only enjoyed it during the season for copulation, still it could not have escaped notice, as these creatures are usually found joined together in the most frequented paths, and in garden-walks.

In different Systems of Natural History the property of shining is attributed to the cancer pulex. The authorities for this opinion are *Hablitzi*, and *Thules* and *Bernard*. The former observed, upon one occasion, a cable that was drawn up from the sea exhibit light, which upon closer inspection was perceived to be covered by these insects‡. *Thules* and *Bernard* reported that they met with

\* *Journal d'Histoire Naturelle*, tome II.

† *Journal de Physique*, tome XVI.

‡ *Hablitzi* ap. *Pall. n. Nord. Beytr.* 4, p. 396.

a number of this species of cancer on the borders of a river entirely luminous †. I am nevertheless disposed to question the luminous property of the cancer pulex, I have often had the animal in my possession, and never perceived it emit any light.

The account by given Linneus of the *scolopendra phosphorea* is so improbable and inconsistent that one might be led to doubt this insect's existence, particularly as it does not appear to have been ever seen, except by Ekeberg, the Captain of an East India-man, from whom Linneus learnt its history.

I now proceed to the description of those luminous animals that have been discovered by the Right Honourable Sir Joseph Banks, Captain Horsburg, and myself.

On the passage from Madeira to Rio de Janeiro, the sea was observed by Sir Joseph Banks to be unusually luminous, flashing in many parts like lightning. He directed some of the water to be hauled up, in which he discovered two kinds of animals that occasioned the phenomenon; the one, a crustaceous insect, which he called the cancer fulgens; the other, a large species of medusa, to which he gave the name of *pellucens*.

The cancer fulgens bears some resemblance to the common shrimp; it is however considerably less; the legs are furnished with numerous setæ. The light of this animal, which is very brilliant, appears to issue from every part of the body.

The medusa *pellucens* measures about six inches across the crown or umbella; this part is marked by a number of opaque lines, that pass off from the center to the circumference.

The edge of the umbella is divided into lobules, which succeed each other, one large and two small ones alternately. From within the margin of the umbella there are suspended a number of long cord-shaped tentacula. The central part of the animal is opaque, and furnished with four thick irregularly-shaped processes, which hang down in the midst of the tentacula.

This zoophyte is the most splendid of the luminous inhabitants of the ocean. The flashes of light emitted during its contractions are so vivid as to effect the sight of the spectator.

In the notes communicated to Sir Joseph Banks by Captain Horsburg he remarks that the luminous state of the sea between the Tropics is generally accompanied with the appearance of a great number of marine animals of various kinds upon the surface of the water; to many of which he does not, however, attribute the property of shining. At other times, when the water which gave out light was examined it appeared only to contain small particles of a dusky straw colour, which dissolved with the slightest touch of the finger. He likewise observes that in Bombay, during the hot weather of May and June, he has frequently seen the edges of the sea much illuminated by minute sparkling points.

At sun-rise on April 12, 1798, in the Arabian sea, he perceived several luminous spots in the water, which conceiving to be animals, he went in the boat and caught one. It proved to be an insect somewhat resembling in appearance the woodlouse, and was about one third of an inch in length. When viewed with the microscope it seemed to be formed by sections of a thin crustaceous substance. During the time that any fluid remained in the ani-

\* Journal de Physique, tome XVI.

† Hablitzl ap. Pall. n. Nord. Beytr. 4, p. 396.

‡ Journal de Physique, tome XXVIII.

mal it shone brilliantly, like the fire-fly.

In the month of June in the same year he picked up another luminous insect on a sandy beach, which was also covered with a thin shell, but it was a different shape, and a larger size than the animal taken in the Arabian sea.

By comparing the above description with an elegant pen and ink drawing which was made by Captain Horsburg, and accompanied his paper, I have no doubt that both these insects were monocoli; the first evidently belongs to the genus *limulus* of Muller; I shall therefore beg leave to distinguish it by the name of *limulus noctilucus*.

My pursuits and the state of my health having frequently led me to the coast, I have had many opportunities of making observations upon the animals which illuminate our own seas. Of these I have discovered three species: one of which is a *beroe* not hitherto described by authors; another agrees so nearly with the *medusa hemispherica* that I conceive it to be the same, or at least a variety of that species; the third is a minute species of *medusa*, which I believe to be the luminous animal so frequently seen by navigators, although it has never been distinctly examined or described.

I first met with these animals in the month of October 1804, at Herne Bay, a small watering place upon the northern coast of Kent. Having observed the sea to be extremely luminous for several nights, I had a considerable quantity of the water taken up. When perfectly at rest, no light was emitted; but on the slightest agitation of the vessel in which the water was contained, a brilliant scintillation was perceived, particularly towards the surface; and when the vessel was suddenly struck, a flash of light issued from the top of

the water, in consequence of so many points shining at the same moment. When any of these sparkling points were removed from the water, they no longer yielded any light. They were so transparent that in the air they appeared like globules of water. They were more minute than the head of the smallest pin. Upon the slightest touch they broke and vanished from the sight. Having strained a quantity of the luminous water, a great number of these transparent corpuscles were obtained upon the cloth, and the water which had been strained did not afterwards exhibit the least light. I then put some sea-water that had been rendered particularly clear, by repeated filtrations, into a large glass, and having floated in it a fine cloth, on which I had previously collected a number of luminous points, several of them were liberated, and became distinctly visible in their natural element, by placing the glass before a piece of dark coloured paper. They were observed to have a tendency to come to the surface of the water; and after the glass was set by for some time, they were found congregated together, and when thus collected in a body they had a dusky straw colour, although individually they were so transparent as to be perfectly invisible, except under particular circumstances. Their substance was indeed so extremely tender and delicate, that they did not become opaque in distilled vinegar or alcohol until immersed in these liquors for a considerable time.

On examining these minute globules with the microscope, I found that they were not quite perfect spheres, but had an irregular depression on one side, which was formed of an opaque substance, that projected a little way inwards, producing such an appearance as would arise from tying the neck of a round

bag, and turning it into the body.

The motions of these creatures in the water were slow and graceful, and not accompanied by any visible contraction of their bodies. After death they always subsided to the bottom of the vessel.

From the sparkling light afforded by this species, I shall distinguish it by the name of *medusa scintillans*.

The night following that on which I discovered the preceding animal, I caught the two other luminous species. One of these I shall call the *beroe fulgens*.

This most elegant creature is of a colour changing between purple, violet, and pale blue; the body is truncated before, and pointed behind; but the form is difficult to assign, as it is varied by partial contractions, at the animal's pleasure. I have represented the two extremes of form that I have seen this creature assume: the first is somewhat that of a cucumber, which, as being the one it takes when at rest, should perhaps be considered as its proper shape: the other resembles a pear, and is the figure it has in the most contracted state. The body is hollow, or forms internally an infundibular cavity, which has a wide opening before, and appears also to have a small aperture posteriorly, through which it discharges its excrement. The posterior two-thirds of the body are ornamented with eight longitudinal ciliated ribs, the processes of which are kept in such a rapid rotatory motion, while the animal is swimming, that they appear like the continual passage of a fluid along the ribs. The ciliated ribs have been described by Professor Mitchell, as arteries, in a luminous *beroe*, which I suspect was no other than the species I am now giving an account of.

When the *beroe fulgens* swam

gently near the surface of the water, its whole body became occasionally illuminated in a slight degree; during its contractions a stronger light issued from the ribs; and when a sudden shock was communicated to the water, in which several of these animals were placed, a vivid flash was thrown out. If the body were broken, the fragments continued luminous for some seconds, and being rubbed on the hand, left a light like that of phosphorus: this however, as well as every other mode of emitting light, ceased after the death of the animal.

The hemispherical species that I discovered, had a very faint purple colour. The largest that I found measured about three quarters of an inch in diameter. The margin of the umbella was undivided, and surrounded internally by a row of pale brown spots, and numerous small twisted tentacula; four opaque lines crossed in an arched manner from the circumference, towards the centre of the animal: an opaque irregular-shaped process hung down from the middle of the umbella: when this part was examined with a lens of high powers, I discovered that it was inclosed in a sheath in which it moved, and that the extremity of the process was divided into four tentacula, covered with little cups or suckers, like those on the tentacula of the cuttle-fish.

This species of *medusa* bears a striking resemblance to the figures of the *medusa hemispherica*, published by Gonovius and Muller; indeed it differs as little from these figures, as they do from each other. Its luminous property, however, was not observed by these naturalists, which is the more extraordinary, as Muller examined it at night, and says it is so transparent, that it can only be seen with the light of a lamp. If it should be still consi-

dered as a distinct species, or as a variety of the hemispherica, I would propose to call it the medusa lucida.

In this species, the central part and the spot round the margin, are commonly seen to shine on lifting the animal out of the water into the air, presenting the appearance of an illuminated wheel, and when it is exposed to the usual percussion of the water, the transparent parts of its body are alone luminous.

In the month of September, 1805, I again visited Herne Bay, and frequently had opportunities of witnessing the luminous appearance of the sea. I caught many of the hemispherical and minute species of medusa, but not one of the berce fulgens. I observed that these luminous animals always retreated from the surface of the water, as soon as the moon rose. I found also, that exposure to the day-light took away their property of shining, which was revived by placing them for some time in a dark situation.

In that season I had two opportunities of seeing an extended illumination of the sea, produced by the above animals. The first night I saw this singular phenomenon was extremely dark; many of the medusa scintillans and medusa hemispherica had been observed at low-water, but on the return of the tide, they had suddenly, disappeared. On looking towards the sea, I was astonished to perceive a flash of light of about six yards broad, extend from the shore, for apparently the distance of a mile and a half along the surface of the water. The second time that I saw this sort of light proceed from the sea, it did not take the same form, but was diffused over the surface of the waves next the shore, and was so strong, that I could for the moment distinctly see my servant, who stood at a little

distance from me: he also perceived it, and called out to me at the same instant. On both these occasions the flash was visible for about four or five seconds, and although I watched for it a considerable time, I did not see it repeated.

A diffused luminous appearance of the sea, in some respects different from what I have seen, has been described by several navigators.

Godeheu de Riville saw the sea assume the appearance of a plain of snow on the coast of Malabar.\*

Captain Horsburgh, in the notes he gave to Sir Joseph Banks, says, there is a peculiar phenomenon sometimes seen within a few degrees distance of the coast of Malabar, during the rainy monsoon, which he had an opportunity of observing. At midnight the weather was cloudy, and the sea was particularly dark, when suddenly it changed to a white flaming colour all around. This bore no resemblance to the sparkling or glowing appearance he had observed on other occasions in seas near the equator, but was a regular white colour, like milk, and did not continue more than ten minutes. A similar phenomenon, he says, is frequently seen in the Banda sea, and is very alarming to those who have never perceived or heard of such an appearance before.

This singular phenomenon appears to be explained by some observations communicated to me by Mr. Langstaff, a surgeon in the city, who formerly made several voyages. In going from New Holland to China, about half an hour after sunset, every person on board was astonished by a milky appearance of the sea: the ship seemed to be surrounded by ice covered with snow. Some of the company supposed they were

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\* Mem. Etrang. de l'Acad. des Sc.  
Tom. 3.

in soundings, and that coral bottom gave this curious reflection; but on sounding with 70 fathoms of line, no bottom was met with. A bucket of water being hauled up, Mr. Langstaff examined it in the dark, and discovered a great number of globular bodies, each about the size of a pin's head, linked together. The chains thus formed did not exceed three inches in length, and emitted a pale phosphoric light. By introducing his hand into the water, Mr. Langstaff raised upon it several chains of the luminous globules, which were separated by opening the fingers, but readily re-united on being brought again into contact, like globules of quicksilver. The globules, he says, were so transparent, that they could not be perceived when the hand was taken into the light.

This extraordinary appearance, of the sea was visible for two nights. As soon as the moon exerted her influence, the sea changed to its natural dark colour, and exhibited distinct glittering points, as at other times. The phenomenon, he says, had never been witnessed before by any of the company on board, although some of the crew had been two or three times round the globe.

I consider this account of Mr. Langstaff very interesting and important, as it proves that the diffused light of the sea is produced by an assemblage of minute medusæ on the surface of the water.

In June, 1806, I found the sea at Margate more richly stored with the small luminous medusæ, than I have ever seen it. A bucket of the water being set by for some time, the animals sought the surface, and kept up a continual sparkling, which must have been occasioned by the motions of individuals, as the water was perfectly at rest. A small quantity of the luminous water was put

into a glass jar, and on standing some time, the medusæ collected at the top of the jar, and formed a gelatinous mass, one inch and a half thick, and of a reddish or mud colour, leaving the water underneath perfectly clear.

In order to ascertain if these animals would materially alter their size, or assume the figure of any other known species of medusæ, I kept them alive for 25 days, by carefully changing the water in which they were placed; during which time, although they appeared as vigorous as when first taken, their form was not in the slightest degree altered, and their size but little increased. By this experiment I was confirmed in the opinion of their being a distinct species, as the young actiniæ and medusæ exhibit the form of the parent in a much shorter period than the above.

In September, 1806, I took at Sandgate a number of the *beroe fulgens*, but no other species: they were of various dimensions, from the full size down to that of the medusa *scintillans*: they could however be clearly distinguished from the latter species, by their figure.

Since that time, I have frequently met with the medusa *scintillans* on different parts of the coast of Sussex, at Tenby, and at Milford haven. I have likewise seen this species in the bays of Dublin and Carlingford, in Ireland.

In the month of April, last year, I caught a number of the *beroe fulgens* in the sea at Hastings; they were of various sizes, from about the half of an inch in length to the bulk of the head of a large pin. I found many of them adhering together in the sea; some of the larger sort were covered with small ones, which fell off when the animals were handled, and by a person unaccustomed to observe these creatures, would



have been taken for a phosphoric substance. On putting a number of them into a glass, containing clear sea water, they still shewed a disposition to congregate upon the surface. I observed that when they adhered together, they shewed no contractile motion in any part of their body, which explains the cause of the pale or white colour of the diffused light of the ocean. The flashes of light which I saw come from the sea at Herne bay, were probably produced by a sudden and general effort of the medusæ to separate from each other, and descend in the water.

The medusa scintillans almost constantly exists in the different branches of Milford haven that are called pills. I have sometimes found these animals collected in such vast numbers in those situations, that they bore a considerable proportion to the volume of the water in which they were contained: thus, from a gallon of sea-water in a luminous state, I have strained above a pint of these medusæ. I have found the sea under such circumstances to yield me more support in swimming, and the water to taste more disagreeably than usual; probably the difference of density, that has been remarked at different times in the water of the sea, may be referred to this cause.

All my own observations lead me to conclude, that the medusa scintillans, is the most frequent source of the light of the sea around this country, and by comparing the accounts of others with each other, and with what I have myself seen, I am persuaded that it is so likewise in other parts of the world. Many observers appear to have mistaken this species for the nereis noctiluca, which was very natural, as they were prepossessed with the idea of the frequent existence of the one,

and had no knowledge of the other. Some navigators have actually described this species of medusa, without being aware of its nature. Mr. Bajon, during his voyage from France to Cayenne, collected many luminous points in the sea, which, he says, when examined by a lens, were found to be minute spheres. They disappeared in the air. Doctor Le Roy, in sailing from Naples to France, observed the sparkling appearance of the sea, which is usually produced by the medusa scintillans. By filtering the water, he separated luminous particles from it, which he preserved in spirits of wine: they were, he says, like the head of a pin, and did not at all resemble the nereis noctiluca, described by Vianelli; their colour approached a yellow-brown, and their substance was extremely tender, and fragile. Notwithstanding this striking resemblance to the medusa scintillans, Le Roy, in consequence of a preconceived theory, did not suppose what he saw were animals, but particles of an oily or bituminous nature\*.

The minute globules seen by Mr. Langstaff in the Indian ocean, were, I think, in all probability, the scintillating species of medusa; and on my shewing him some of these animals I have preserved in spirits, he entertained the same opinion.

Professor Mitchell, of New York, found the luminous appearance on the coast of America, to be occasioned by minute animals, that from his description, plainly belonged to this species of medusæ, notwithstanding which, he supposed them to be a number of the nereis noctiluca†.

The luminous animacule discover-

\* Observ. sur un lumiere produite par L'Eau de la mer. Mem. Etrang. des Sc.

† Phil. Mag. Vol. X. p. 20.

ed by Forster off the Cape of Good Hope, in his Voyage round the World, bears so strong a resemblance to the medusæ scintillans, that I am much disposed to believe them the same. He describes his animalcule as being a little gelatinous globule, less than the head of a pin; transparent, but a little brownish in its colour; and of so soft a texture that it was destroyed by the slightest touch. On being highly magnified, he perceived on one side a depression, in which there was a tube that passed into the body, and communicated with four or five intestinal sacs. The pencil drawings he made on the spot, are in the possession of Sir Joseph Banks, by whose permission, engravings from them are subjoined to this paper. By comparing these with the representations of the medusa scintillans, and some of this species rendered visible, by being a long time preserved in spirits, which I have laid before this learned society, it will be found, that the only difference between Forster's animalcule, and the medusa scintillans, is in the appearance of the opaque parts, shewn in the microscopic views.

Many writers have ascribed the light of the sea to other causes than luminous animals. Martin supposed it to be occasioned by putrefaction; Silberschlag believed it to be phosphoric; Professor J. Mayer conjectured that the surface of the sea imbibed light, which it afterwards discharged. Bajon and Gentil thought the light of the sea was electric, because it was excited by friction. Forster conceived that it was sometimes electric, sometimes caused from putrefaction, and at others by the presence of living animals. Fougereux de Bondaroy believed that it came sometimes from electric fires, but more frequently from the

putrefaction of marine animals and plants.

I shall not trespass on the time of the Society to refute the above speculations; their authors have left them unsupported by either arguments or experiments, and they are inconsistent with all ascertained facts upon this subject.

The remarkable property of emitting light during life, is only met with amongst animals of the four last classes of modern naturalists, viz. Mollusca, Insects, Worms, and Zoophytes.

The mollusca and worms contain each but a single luminous species; the *pholas dactylus* in the one, and the *neris noctiluca* in the other.

Some species yield light, in the eight following genera of insects: *elater*, *lampyris*, *fulgora*, *pausus*, *scolopendra*, *cancer*, *lynceus*\*, and *limulus*. The luminous species of the genera *lampyris* and *fulgora* are more numerous than is generally supposed, if we may judge from the appearance of luminous organs, to be seen in dried specimens.

Amongst zoophytes we find that the genera *medusa*, *beroe*†, and *penatula*, contain species which afford light.

The only animals which appear to possess a distinct organization for the production of light, are the luminous species of *lampyris*, *elater*, *fulgora*, and *pausus*.

The light of the lampyrides is known to proceed from some of the last rings of the abdomen, which, when not illuminated, are of a pale

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\*The animal discovered by Riville off the coast of Malabar in 1754, is certainly a testaceous insect, and appears to belong to the genus *lynceus* of Muller.

†The luminous zoophyte for which Peron has lately instituted the new genus *pyrosoma*, appears to me to be a *beroe*, and only worthy of a specific distinction.

yellow colour. Upon the internal surface of these rings there is spread a layer of a peculiar soft yellow substance, which has been compared to paste, but by examination with a lens I found it to be organized like the common interstitial substance of the insect's body, except that it is of a closer texture, and a paler yellow colour. This substance does not entirely cover the inner surface of the rings, being more or less deficient along their edges, where it presents an irregular waving outline. I have observed in the glow-worm that it is absorbed, and its place supplied by common interstitial substance, after the season for giving light is past.

The segments of the abdomen, behind which this peculiar substance is situated, are thin and transparent, in order to expose the internal illumination.

The number of luminous rings varies in different species of *lampyris*, and, as it would seem, at different periods in the same individual.

Besides the luminous substance above described, I discovered in the common glow-worm, on the inner side of the last abdominal ring, two bodies, which to the naked eye ap-

pear more minute than the head of the smallest pin. They are lodged in two slight depressions, formed in the shell of the ring, which is at these points particularly transparent. On examining these bodies under the microscope I found that they were sacs containing a soft yellow substance, of a more close and homogeneous texture than that which lines the inner surface of the rings. The membrane forming the sacs appeared to be of two layers, each of which is composed by a transparent silvery fibre, in the same manner as the internal membrane of the respiratory tubes of insects; except that in this case the fibre passes in a spiral instead of a circular direction. This membrane, although so delicately constructed, is so elastic as to preserve its form after the sac is ruptured and the contents discharged.

The light that proceeds from these sacs is less under the controul of the insect than that of the luminous substance spread on the rings: it is rarely ever entirely extinguished in the season that the glow-worm gives light, even during the day; and when all the other rings are dark, these sacs often shine brightly.

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